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Patterns of Authorship and Scientific Collaboration in Education: The Production of Colombia in ESCI

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Abstract:
This paper aims to carry out a bibliometric study on the scientific production on Education that occurs in Colombia and it is indexed in the Emerging Sources Citation Index (ESCI) database. To carry out this study, the data related to the documents indexed in the ESCI database of WoS were downloaded and, by counting frequencies, the patterns of document production by journal and by year, the most productive institutions, the indicators of collaboration in authorship and the type of collaboration were identified. An increase in co-authorship and collaboration rates, as well as in international collaboration was detected for the examined period. The public universities were identified as the leading generators of scientific production in Education in Colombia. Likewise, the Bradford's core of zones of dispersion of literature in the topic was identified, and it was found that more than 90% of these are journals edited by universities. The production of Colombia in Education has experienced a considerable increase in the period from 2005 to 2019. Although the collaboration rates have increased and are similar to those observed for example in Education in Spain, they are still lower than those of Social Sciences in Colombia.

Keywords: Education, Bibliometry, scientific production, Colombia, ESCI, collaboration

Introduction

It is a fact the need of bibliometric studies which allow knowing the state of a field of knowledge and the production patterns of countries, regions or institutions. On the one hand, these studies will allow them to recognize their strengths and on the other hand, they may take political, scientific or methodological measures that might overcome biases or possible deficiencies in that field.

Bibliometric studies should be considered powerful tools that help in the evaluation processes of researchers, research centers or the scientific fields themselves. Although these studies had their origin and greater application in areas of Science, in the last two decades bibliometric studies focused on Social Sciences have increased (Bornmann, Thor, Marx, & Schier, 2016; Tripathi, Kumar, & Babbar, 2018; Taga, Oliveira, Rodríguez, Uriona, & Varvakis, 2017). However, their application in Social Sciences is still viewed with suspicion in some sectors (Archambault, & Larivière, 2010).

Scientific production in Education has been analyzed in various contexts. For example, a particular journal has been studied (Earp, 2010; Gutiérrez-Rubio, Maz-Machado, León-Mantero, & Madrid, 2019), a set of journals (Madrid, Jiménez-Fanjul, León-Mantero, & Maz-Machado, 2017), the quality of higher education in a country (Adams, 2009) or a specific field like mathematical education in Latin America (Torres-Alfonso, Peralta-González, & Toscano-Menocal, 2014) or nursing education in Brazil (Prado, Medina-Moya, & Martínez-Riera, 2011).
In this manner, we have a wide range of examples focused on bibliometric research on Education, from case studies (focused on a single journal) to macro studies such as

Fairbairn et al. (2009), who analyzed 1042 journals. Diem and Wolter (2013) consider that the use of bibliometric data for the assessment of the research performance on educational research is justified as long as bibliometry is not too indiscriminate in terms of the quality of the material included.

Most of this bibliometric research has been focused on data from international databases such as WoS and Scopus, but the bias of these sources is well known for journals from non-English-speaking countries. In order to try to limit this bias, Clarivate Analytics, the WoS provider, has incorporated other databases with a more marked regional character such as KCI - Korean Journal Database, Russian Science Citation Index, or SciELO Citation Index. It has also put into service the Emerging Sources Citation Index (ESCI), a product that has been incorporated into the Web of Science. ESCI includes all those journals that are in a study phase for their possible incorporation into JCR (Journal Citation Report).

It is necessary to study and analyze the information offered in these latest databases to understand their potential and usefulness in the processes of evaluation of scientific production. For this reason, we have carried out an analysis on the production related to Education performed in Colombia and indexed in ESCI, although some studies on SCI have already being carried out (Muñoz-Ñungo, Rodríguez-Faneca, & Gutiérrez-Rubio, 2018; Okagbue *et al*., 2018), they are still scarce.

Objectives

The objectives of this study are:

1. Know Colombia's diachronic production in Education at ESCI.
2. Identify the most productive institutions.
3. Determine some indicators of collaboration in authorship.
4. Identify the journals included in SCI in which Colombian Education researchers publish.
5. Determine the type and scope of collaboration at the institution level.

Methodology

We present an exploratory and descriptive study. In February 2020, the WoS website was consulted and in its main collection, the Emerging Sources Citation Index database was selected. A search was made filtering by “Colombia” in address and “Education” in the subject. The search was limited between 2005, the first year of information in ESCI, to 2019, obtaining 36277 records. Those corresponding to the categories *Education & Educational Research; Education, Scientific Disciplines* were selected. The filtering yielded a total of 4272 records, of which 4080 are articles. From now on, we will generically call all the results documents without discriminating their type. The information was downloaded into a database in an Excel spreadsheet and processed using software written specifically for this task.

Subsequently, a process of standardization of the names of some educational institutions was carried out since, sometimes, distinct variants were found for the same university. This process required an exhaustive review of the different names that the authors indicate for the same university, so the results differ from those offered by WoS through the option of analysis of results. As an example, 10 denominations were found for the Universidad Distrital Francisco José de Caldas: Univ Distrital Francisco Jose Calden, Univ Francisco

José Caldas, Univ Francisco Caldas Bogotá, Univ Dist Francisco José de Caldas, Universidad Distrital Francisco José de Caldas, Univ Francisco José de Caldas, Univ Dis Francisco Caldas, Univ Dist Francisco José Caldas de Colombia; Univ Dist Francisco Jost De Caldas y Univ Francisco Jose Caldas.

Likewise, there are universities with similar names or identical names, but from different countries such as Universidad de Los Andes Chile; Universidad Andes Táchira (Venezuela), and Universidad de los Andes (Colombia).

The variables that were considered were: the year, the affiliation of the authors, the name of the journal, the number of authors per document, the language of publication, and the country of each signer.

The affiliation of the signatory authors was taken into account to identify the collaboration that occurs between universities and then, the collaboration network was represented using the VOSviewer software (Version 1.6.15; Van Eck & Waltman, 2020). Collaboration between countries was determined by the number of authors in each country.

The number of authors for each article was counted in order to determine the following indicators: The IC Collaboration Index (Lawani, 1980), which is a measure of the average number of authors; the DEGREE of collaboration GD (Subramanyan, 1983), which is a measure of the proportion of multiple authors; and finally the CC Collaboration Coefficient (Ajiferuke, Burrel, & Tague, 1988), which was designed to eliminate some related problems that these authors pointed out about IC and GD. These are determined from the following mathematical formulas:

$$aa\ IC = \frac{\sum_{j=1}^{A} j f_j}{N}; \quad CC = 1 - \frac{\sum_{j=1}^{A} \left(\frac{1}{j}\right) f_j}{N}; \quad GC = 1 - \frac{f_1}{N}$$

Where

f_j = Number of articles with exactly j authors in the collection k.

N = Number of articles in k. $N = \sum_j f_j$.

A = Number of authors in *k*

Results and Discussion

Production

In the period studied, from 2005 to 2019, it was found that the scientific production in Education carried out in Colombia and published in the journals indexed in ESCI was formed by 4272 documents. The diachronic analysis reveals that there has been a gradual increase, although this increase has not been continuous because it had a minimum point in 2006 and reached the peak of production in 2019 (Figure 1). The general production pattern denotes that the best fit for a deterministic model is a linear growth (R-2-0.904), with cycles of increase and decrease. Also, different rates of year-on-year variation (TVI) were observed. The highest value of TVI's 50.35 occurred in 2013, and the lowest TVI-15.80 occurred in 2014. In general, the number of articles has increased from 96 to 433 in the period from 2005 to 2019. Therefore, the last five years concentrates more than half of all publications in Education in Colombia (56.0%).

Although an increase in production has been found, it has not been followed by an

increase in citations in the same proportion. The number of cites increased from 17 in 2005 to 32 in 2019. 81.03% of the documents have not received a citation, and 10.22% have received only one. This percentage of non-cited documents is similar to the percentages of production written in Spanish (Table 1) and this could be one of the possible explanations.

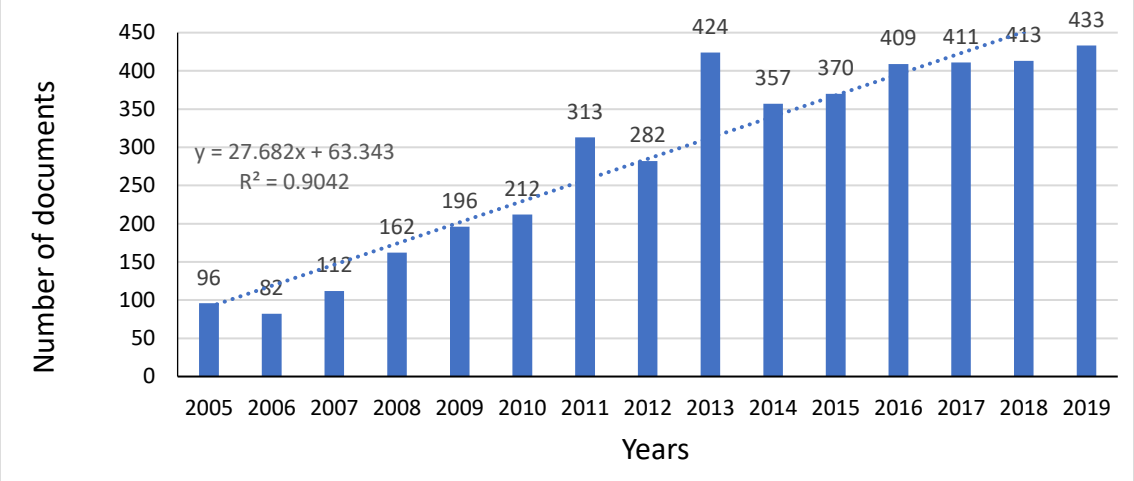

Figure 1. Evolution of the number of documents per year.

The documents were written mostly in Spanish (86.31%), followed remotely by English (11.9%) (Table 1). Although there are documents published in 8 other languages, their number is almost anecdotal, because they represent less than 2% of the total.

Table 1. *Publication language*

Languages	Nº documents	%
Spanish	3687	86.31
English	512	11.99
Portuguese	54	1.26
Others	19	0.44
Total	4272	

Collaboration

The documents were signed by 753 different authors who gave a total of 9049 signatures. The average is 2.11 authors per document. This value is very close to the value of 2 that Bordons and Gómez (1997) established for Social Sciences in the 90s and the 2.06 determined in the category of Urban Studies in WoS (Maz-Machado & Jiménez-Fanjul, 2018a).

If we compare the results found in other studies on production in Education, Anta (2008) determined that the average for publications about Education in Spanish journals had an average of 1.8 authors. Fernández-Cano (2011) obtained an average of 1.9 authors per article for the Spanish production of Education in SSCI. However, Robinson-García and Amat (2017) estimated that the value for Spain was 2.9 authors per paper in Social Sciences and Education. So the average of authors per article in Colombia in publications on Education is similar to the one in Spain ten years ago, but it is less than the average in Spain nowadays.

If we analyzed the number of authors in detail, it is found that 43.45% papers have a single author, and those signed by two or three authors represent 45.65% of the total. The pattern of authorship has changed over the studied period; in 2005 the publication of documents with single authorship (61.46%) was higher than the number of documents with multiple authorship (38.54%). This relation is reversed in 2019 with only 22.40% single authorship versus 75.60% co-authorship. In the last year, 17.55% of the documents had four or more authors (Table 2).

Table 2. *Authorship patterns in Education in Colombia at ESCI.*

Year	Single author	Two authors	Three authors	Four authors	Five authors	6 or more authors	Total documents
2005	59	24	9	2	1	1	96
2006	52	13	9	3	3	2	82
2007	75	24	5	2	1	5	112
2008	99	41	13	4	4	1	162
2009	108	52	23	5	3	5	196
2010	116	41	33	10	8	4	212
2011	187	71	32	14	5	4	313
2012	146	65	49	8	9	5	282
2013	184	120	76	31	4	9	424
2014	157	96	72	21	6	5	357
2015	149	97	85	22	10	7	370
2016	156	108	98	24	13	10	409
2017	137	124	106	23	12	9	411
2018	134	109	95	31	17	27	413
2019	97	134	126	40	12	24	433
Total	1856	1119	831	240	108	118	4272

From the data in Table 2, the values of the three most frequent collaboration indicators in the literature were determined. Thus, the Degree of Collaboration in the period is GD = 0.79. The minimum value was in 2007 and the maximum in 2019 (Table 3). This value is close to the one obtained for the GD (0.75) in the Colombian scientific publications in SciELO (Maz-Machado, Jiménez-Fanjul, & Villarraga-Rico, 2016).

The IC reached its minimum value in the years 2005 and 2008 and its maximum in 2019. The value for the period is IC = -1.68. This value is far lower than the one found for collaboration in Colombian publications indexed in WoS between 2005 and 2016, which it reached an IC value = 6.46 (Maz-Machado & Jiménez-Fanjul, 2018b).

The collaboration coefficient for the whole period is CC = 0.35, which is low compared to the other two indicators. This is not contradictory since it must be recalled that the CC is based on the idea of the fractional attribution of productivity in the production of documents and to supply supposed deficiencies of the GD and IC (Savanur & Srikanth, 2010; Alvarado, 2011).

Table 3. *Collaboration measures.*

Year	GD	CC	IC
2005	0.62	0.22	1.02
2006	0.65	0.23	1.20
2007	0.61	0.20	1.05
2008	0.63	0.22	1.02
2009	0.70	0.26	1.30
2010	0.71	0.28	1.36
2011	0.65	0.24	1.10
2012	0.73	0.29	1.39
2013	0.79	0.34	1.62
2014	0.78	0.34	1.57
2015	0.81	0.37	1.75
2016	0.83	0.38	1.84
2017	0.85	0.41	1.94
2018	0.88	0.43	2.29
2019	0.92	0.49	2.42
2005 - 2019	0.79	0.35	1.68

In order to know how the dispersion of Colombian publications on Education in ESCI is, among other aspects to know which are the journals that form the main channel of dissemination of this area of research. For this, we applied the dispersion law of the scientific literature or Bradford's Law (1948) and we determined the different areas. In three of the documents studied, the name of the journal was not indicated and, therefore, they were not included in this part of the research. Data regarding the productivity of documents published in journals were analyzed. Table 4 shows the distribution of the journals according to the production of documents.

Table 4. *Distribution of journals according to the publication of documents.*

Journals= a	Docs= b	$a \times b$	Accumulated journals = c	$\ln c$	Accumulated documents
1	193	193	1	0.0000	193
1	179	179	2	0.6931	372
1	143	143	3	1.0986	515
1	123	123	4	1.3863	638
1	119	119	5	1.6094	757
1	107	107	6	1.7918	864
1	82	82	7	1.9459	946
1	75	75	8	2.0794	1021
1	72	72	9	2.1972	1093
1	70	70	10	2.3026	1163
1	68	68	11	2.3979	1231
1	66	66	12	2.4849	1297
1	57	57	13	2.5649	1354
1	53	53	14	2.6391	1407
2	51	102	16	2.7726	1509

1	46	46	17	2.8332	1555
1	43	43	18	2.8904	1598
1	42	42	19	2.9444	1640
1	40	40	20	2.9957	1680
1	39	39	21	3.0445	1719
1	38	38	22	3.0910	1757
5	36	180	27	3.2958	1937
2	33	66	29	3.3673	2003
4	32	128	33	3.4965	2131
1	30	30	34	3.5264	2161
1	27	27	35	3.5553	2188
1	26	26	36	3.5835	2214
2	25	50	38	3.6376	2264
3	24	72	41	3.7136	2336
1	21	21	42	3.7377	2357
1	20	20	43	3.7612	2377
3	19	57	46	3.8286	2434
2	18	36	48	3.8712	2470
2	17	34	50	3.9120	2504
2	16	32	52	3.9512	2536
3	15	45	55	4.0073	2581
7	14	98	62	4.1271	2679
5	13	65	67	4.2047	2744
11	12	132	78	4.3567	2876
12	11	132	90	4.4998	3008
7	10	70	97	4.5747	3078
14	9	126	111	4.7095	3204
8	8	64	119	4.7791	3268
12	7	84	131	4.8752	3352
11	6	66	142	4.9558	3418
18	5	90	160	5.0752	3508
37	4	148	197	5.2832	3656
55	3	165	252	5.5294	3821
84	2	168	336	5.8171	3989
280	1	280	616	6.4232	4269

In Figure 2, we illustrate the Bradford's Law. The horizontal axis represents in log-scale the number of journals accumulated in descending order of productivity and the vertical axis represents the cumulative number of articles. The resulting curve of the cumulative number of documents by $R(r)$ journals is monotonous and increasing.

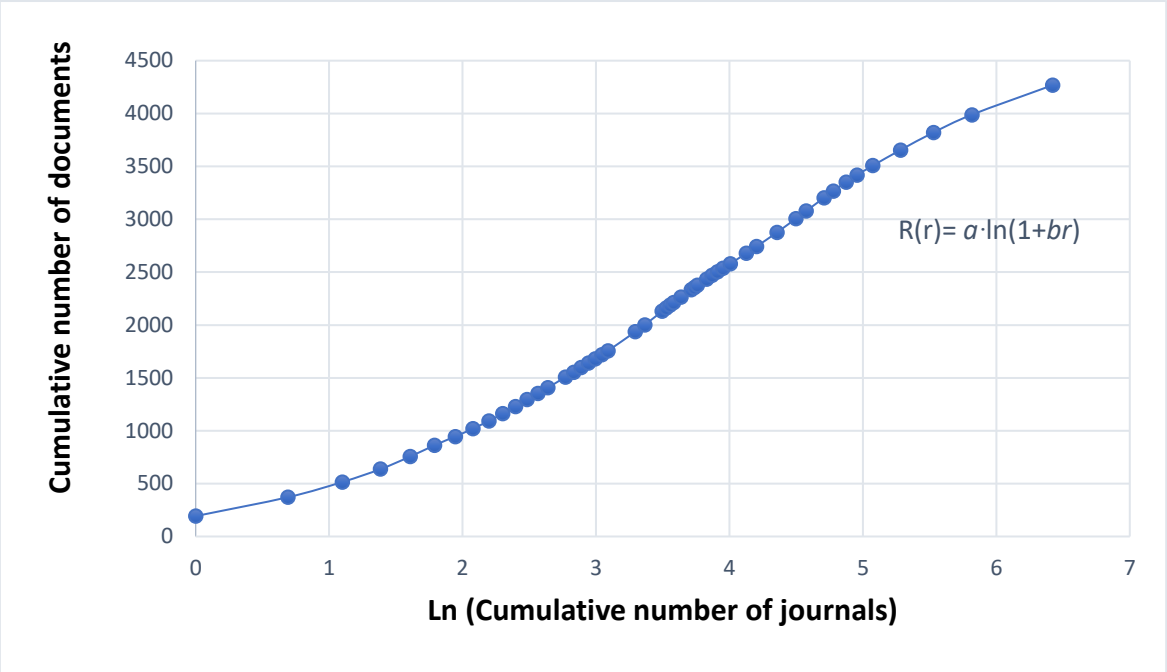

Figure 2. Dispersion of scientific production, according to Bradford's Law.

Since Bradford did not state his law using algebraic expressions, we are going to find the so-called Bradford's zones using Leimkuhler's Law (1967) who expressed it in mathematical terms: $R(r) = a \cdot \ln(1 + b \cdot r)$. For this purpose, we will follow the procedure proposed by Egghe (1986), which has been tested in other studies (Pinto, Escalona, Pulgarín & Uribe-Tirado, 2015).

If we consider that:
r_0 is the number of journals in the first Bradford's area
y_0 is the number of items in each Bradford's zone (each zone must be of equal size)
K is Bradford's multiplier.
$R(r)$ is the cumulative number of articles published by the journals
a and b are the constants of the Leimkuhler' formula: $R(r) = a \cdot \ln(1 + b \cdot r)$.

Egghe (1986) indicated that the following formulas should be considered to find the values of the constants a and b: $a = \frac{y_0}{\ln(k)}$ and $b = \frac{k-1}{r_0}$. First, we determine the number of Bradford's zones we want to find, namely $p = 3$. Now we can find the value of k, following Egghe (1990):

$$k = (e^{\gamma} \cdot y_m)^{1/p}$$

where γ is the Euler's Constant, $\gamma = 0.5772$, so that $e^{\gamma} = 1.781$.

$k = (1.781 \cdot y_m)^{1/p} = (1.781 \cdot 193)^{1/3} = (343.733)^{1/3} = 7.004$

$r_0 = \frac{T}{1+k+k^2+\cdots+k^{p-1}} = \frac{T \cdot (k-1)}{k^p - 1}$, where T is the number of journals.

$$r_0 = \frac{T \cdot (k-1)}{k^p - 1} = \frac{616 \cdot (7.004 - 1)}{7.004^3 - 1} = \frac{3698.464}{342.588} = 10.79$$

Once the values of k and r_0 are obtained, we proceed to find a and b.

$$a = \frac{(2170/3)}{\ln(7.004\ )} = \frac{723.333}{1.946} = 371.70 \quad \text{and} \quad b = \frac{7.004 - 1}{10.7957} = 0.556$$

To calculate the number of journals in each of the Bradford's zones $(r_0, k \cdot r_0, k^2 \cdot r_0, \ldots)$, Egghe (1990) recommended using the exact values of r_0 and k and therefore, also the values from a and b in the formula of Leimkuhler's law.

$$R(r) = a \cdot \ln(1 + b \cdot r) = 371.70 \cdot \ln(1 + 0.556 \times 616)$$
$$= 371.70 \cdot 5.83 = 2167.01$$

Table 5. *Journal distribution in Bradford's zones.*

Zones	Journals	Documents	K
Core	11	1231	--
1ist zone	76	1645	6.90
2nd zone	529	1393	6.96
Total	616	4269	

The distribution of all journals in the three Bradford's zones is presented in Table 5. The core contains 11 journals that accumulate 1231 documents which are listed in Table 6. This core consists of journals edited by the universities themselves, except for *Logos Ciencia & Tecnología* published by the Colombian National Police.

Table 6. *Journals that form the Bradford's core.*

	Journal	Nº Docs	%
Bradford's Core	*Uni-Pluriversidad*	193	4.5
	Revista Científica	179	4.2
	Revista Virtual Universidad Católica del Norte	143	3.3
	Praxis & Saber	123	2.9
	Revista Educación en Ingeniería	119	2.8
	Actualidades Pedagógicas	107	2.5
	Infancias Imágenes	82	1.9
	Magis-Revista Internacional de Investigación en Educación	75	1.8
	Zona Próxima	72	1.7
	Logos Ciencia & Tecnología	70	1.6
	Sophia-Educación	68	1.6

Considering that most of Colombian universities offer university programs related to Education, the most productive were determined according to the data. The Universidad de Antioquia is the largest producer with 11.68% of the total, followed by the Universidad Nacional de Colombia with 7% and the Universidad Distrital Francisco José de Caldas

with 6.67% (Table 7), all of them are publics universities. The first private university according to productivity is the Pontificia Universidad Javeriana. The first 10 universities produce 51.25% of the documents.

Table 7. *Colombian universities with higher production in Education in ESCI.*

University	Nº Documents	%
Universidad de Antioquia	499	11.68
Universidad Nacional de Colombia	299	7.00
Universidad Distrital Francisco José de Caldas	285	6.67
Universidad Pedagógica Nacional	271	6.35
Pontificia Universidad Javeriana	216	5.06
Universidad Pedagógica y Tecn. De Colombia	196	4.59
Universidad del Valle	151	3.54
Universidad de Los Andes	146	3.42
Universidad de La Salle	126	2.95
Universidad Industrial de Santander	114	2.67
Universidad Santo Tomás	107	2.51
Universidad del Norte	92	2.15
Universidad Pontificia Bolivariana	88	2.06
Universidad Cooperativa de Colombia	77	1.80
Universidad San Buenaventura	72	1.69
Universidad de Caldas	70	1.64
Universidad de La Sabana	70	1.64
Corp. Universitaria Minuto de Dios Uniminuto	66	1.55
Universidad del Magdalena	66	1.55
Universidad del Quindío	62	1.45
Universidad del Cauca	61	1.43
Universidad Militar Nueva Granada	58	1.36
Universidad Manizales	55	1.29
Universidad Tecnológica De Pereira	55	1.29
Universidad del Rosario	52	1.22

In Figure 3, the collaboration map between universities and institutions in the scientific production on Education in Colombia with at least ten or more collaborations is presented.

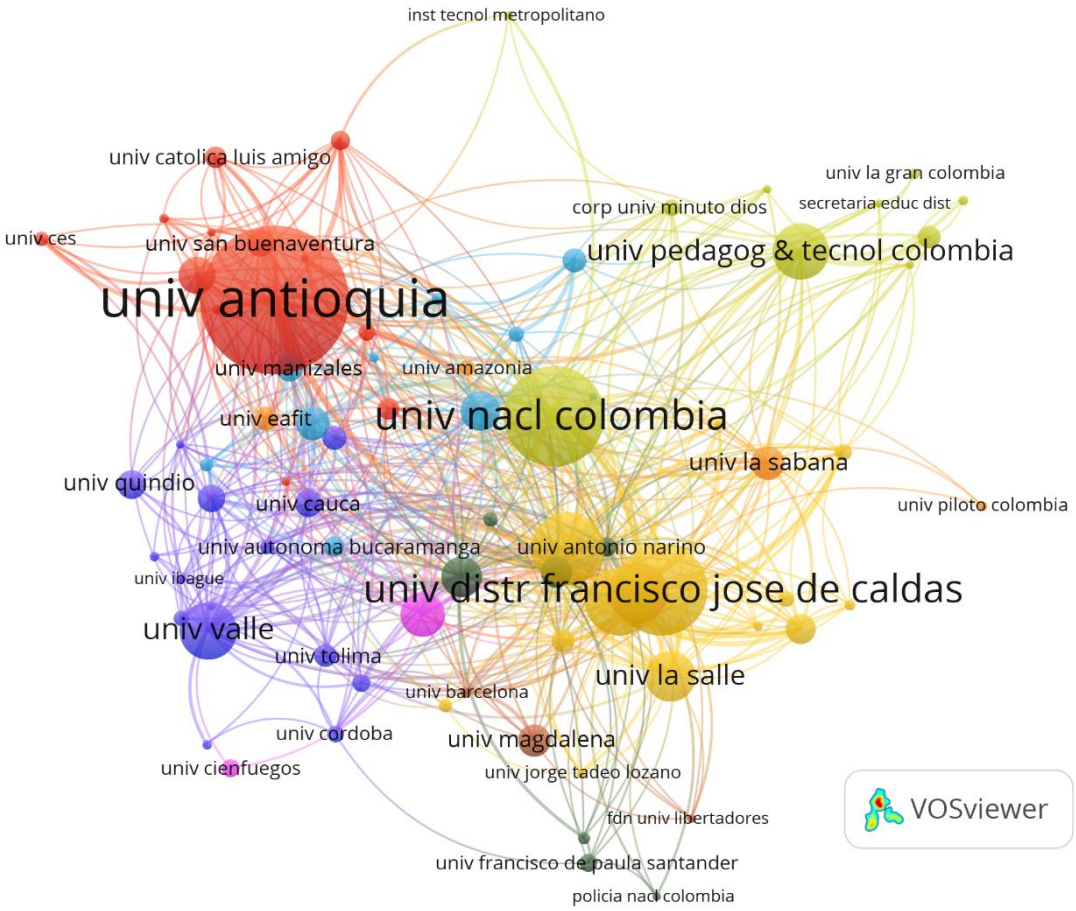

Figure 3. Collaboration map between institutions ≥ 10

The analysis of types of collaboration established in the documents reveals the increase in institutional collaboration, both internationally and nationally; both types surpassing documents without collaboration. At the beginning of the period analyzed in 2005, 47.9% of production was carried out without external collaboration to the institutions themselves. The year 2019 reached 34.4% (Figure 4). The highest percentage of collaboration occurred in 2019 with 79.4%.

The annual average of documents without collaboration is 38.7%, which is considerably higher than the one found in Colombian publications in Social Sciences in SciELO which is 20.9 (Maz-Machado & Jiménez-Fanjul, 2018b).

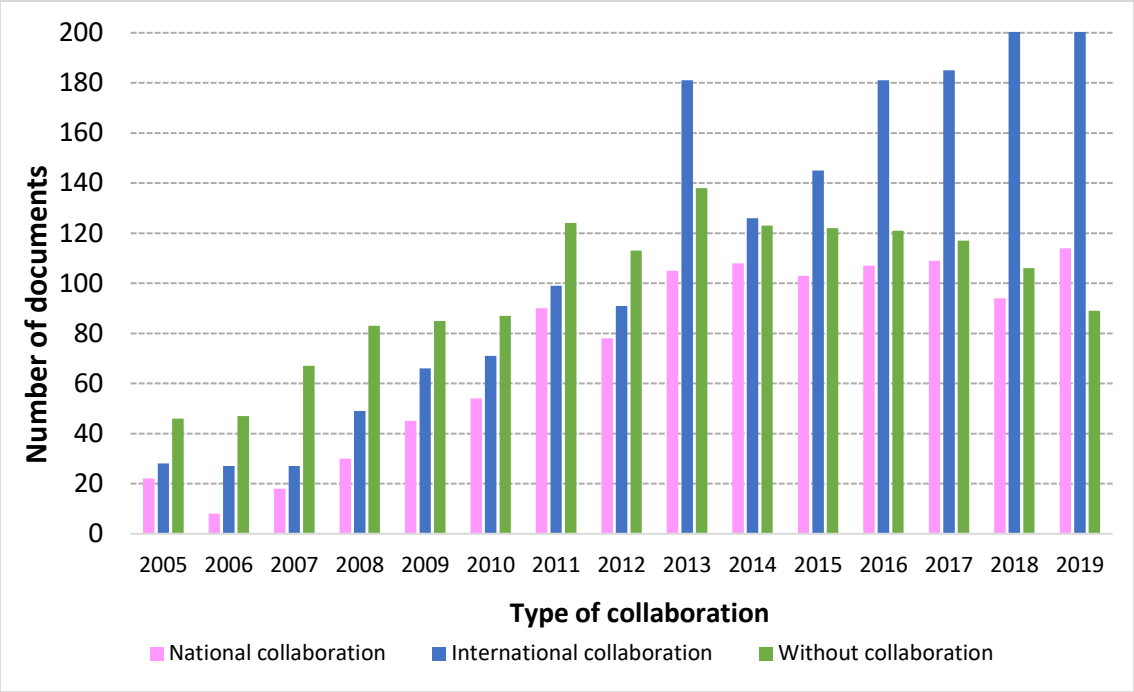

Figure 4. Types of institutional collaborations

Conclusions

The production of Colombia in Education has had a considerable increase in the period 2005 to 2019, although in the last four years, its increase has been small, not reaching 10% and has tended to stabilize around 415 documents per year.

Two of the three collaboration indexes indicate an increase in production, and this is substantiated by the increase in national and international institutional collaboration. It was found that public universities lead publications in Education. The Universidad de Antioquia is positioned as the leading institution in educational scientific production in Colombia, publishing 66% more than the second-ranked university in the list.

When the scientific dispersion was established by determining the Bradford's zones, it was found that the core of dissemination of the research is made of 11 journals, all of them with a Colombian Editorial and 10 of them are related to universities.

The evaluation and monitoring systems of research in Colombia should establish criteria and suggestions in order to uniform the way of designating the institutional affiliation of an author when he signs a publication, this will allow a more significant and easier way of tracing the production, both in an institution or in a country level.

In conclusion, we can affirm that the ESCI database offers valuable information at the same level of other more that are more used. Therefore it allows us to identify patterns and trends in production, as well as in the channels of dissemination of research in the field of Social Sciences and in this case on Education.

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